PROTEÇÃO CONTRA RADIAÇÕES NA COMUNIDADE DOS PAÍSES DE LÍNGUA PORTUGUESA

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Quantification of potassium-40 in soils from São Paulo state conservation units, Brazil

Quantificação de potássio-40 em solos de unidades de conservação do estado de São Paulo, Brasil

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KEYWORDS: radionuclides, tracer, Cerrado, Atlantic Forest, Dense Ombrophilous Forest, ^{40}K

ABSTRACT: Soil is the main reservoir of chemical substances for vegetation, however little is known about the distribution of natural radionuclides in well preserved areas such as conservation units. Among the radionuclides, ^{40}K can be an interesting tracer of the nutrient potassium, besides it can be useful to check mineral cycling of ecosystems. In this work the activity concentration of ^{40}K was determined in soils of two conservation units corresponding to Cerrado and

Atlantic Forest biomes, located in São Paulo State, Brazil. Soil samples were collected under crown projection of the most abundant trees species of long-term plots installed within the EstaçãoEcológica de Assis (Cerrado type biome) and Parque Estadual Carlos Botelho (Atlantic Forest biome). Samples were oven-dried and milled in a porcelain mortar. The radioactivity present in test portions was measured using an HPGe detector from Canberra. Results of ^{40}K were lower than 77 Bq $kg^{-1}$for Cerrado soils, while, for the Atlantic Forest, results were in the range of 760 Bq kg^{-1} to 1440 Bq kg^{-1}. Such difference could be explained by the degree of soil development, since most part of Atlantic Forest soils are inceptisol, that is, soils with the typical presence of parent material from rock weathering. Besides, it can be assumed that potassium in soil can be limiting for Cerrado ecosystems.

PALAVRAS-CHAVE: radionuclídeos, traçador, Cerrado, Mata Atlântica, Floresta Ombrófila Densa, ^{40}K

RESUMO: O solo é o principal reservatório de substâncias químicas para a vegetação, contudo, pouco se conhece sobre a distribuição natural dos radionuclídeos em áreas bem preservadas, tais como as unidades de conservação. Entre os radionucídeos, ^{40}K pode ser um traçador de interesse para o nutriente potássio, também útil na monitoração da ciclagem mineral nos ecossistemas. Neste trabalho, a concentração da atividade do ^{40}K foi determinada em solos de duas unidades de conservação dos biomas Cerrado e Mata Atlântica, localizados no estado de São Paulo, Brasil. As amostras de solo foram coletadas sob a projeção da copa das espécies de árvores mais abundantes de parcelas instaladas há longo tempo na Estação Ecológica de Assis (Bioma Cerrado) e no Parque Estadual Carlos Botelho (Bioma Mata Atlantica).

As amostras foram secas em forno e cominuídas em almofariz de porcelana. A radioatividade presente nas porções-teste foi medida em um detector HPGe da Canberra. Os resultados do ^{40}K mostraram uma

1. INTRODUCTION

Radionuclides can be transferred from soil to plants, and, therefore, to man by means of the food chain (Koranda and Robinson, 1978). In fact, soil-to-plant transfer is an important way of human exposure to radionuclides (Velasco et al., 2004). So, the knowledge about the soil radionuclide composition allows tracking the radionuclides route until their uptake by humans. Besides, radionuclides can be useful to trace stable chemical elements, which are nutrients for plants and animals.

^{40}K is an interesting tracer for stable K, which is an important nutrient to plants and animals, being involved in many physiological functions such as enzyme activation, protein synthesis and osmoregulation. Under potassium starvation conditions, plants cannot complete their life cycle (Velasco et al., 2012).

There is a lack of studies about the ^{40}K distribution in soils from natural areas (Velasco et al., 2012), specially conservation units, which are protected areas with natural resources of great interest for biodiversity conservation. Cerrado and Atlantic Forest biomes are Brazilian hotspots of global biodiversity (Coutinho et al., 2015), thus being of utmost relevance for radionuclides monitoring.

The objective of this research was to determine the activity concentration of ^{40}K in soils of two conservation units corresponding to Cerrado and Atlantic Forest, located in São Paulo State, Brazil.

2. MATERIAL AND METHODS

For sampling, about 30 soil samples were taken at 0-10 cm depth under crown projection of the most abundant trees species of long-term plots installed within the Estação Ecológica de Assis (Cerrado type biome) and Parque Estadual Carlos Botelho (Atlantic Forest biome), located in São Paulo State, Brazil. Both units were inserted into the Biota Project "Diversity, dynamic and conservation of forests from the São Paulo State: 40 ha of long-term plots", from the São Paulo State Foundation – FAPESP (França et al., 2010).

With an area of approximately 1,300 ha, the Estação Ecológica de Assis (Assis Ecological Station) is situated in the municipality of Assis, São Paulo state, Brazil, representing the Cerrado physiognomy, characterized by trees forming a continuous canopy (up to 15 m height), with absence of grasses. The predominant soil types in this area were Inceptsol and Oxisol. The climate is Cwa type of Köppen's classification (Bertolucci et al., 2007).

The Parque Estadual Carlos Botelho (Carlos Botelho State Park) is located in the southern region of the São Paulo State, Brazil, in the municipalities of São Miguel Arcanjo, Capão Bonito and Sete Barras. Dense ombrophilous forest is the predominant vegetational type and the soil in this region is Inceptsol class. The climate is the Cfa type of Köppen's classification (Bertolucci et al., 2007).

Samples were oven-dried at 60 °C and milled in a porcelain mortar until 0.5 mm particle size. Test portions of 30 g were placed in polypropylene vials and sealed with silicone. The radioactivity was measured using a high-purity germanium detector (HPGe), model GC4019 from Canberra®. The activity concentration of ^{40}K was measured during 80,000 seconds at the photopeak of 1460.82 keV. The software Genie 2000 was used for calculation taking into account an efficiency curve previously obtained. The quality of the analytical procedure was evaluated according to the Internal

Standard Soil from the National Intercomparison Program of the Institute of Radiation Protection and Dosimetry (IRD).

3. RESULTS

The behavior of ^{40}K in the environment is the same as other potassium isotopes, and this radionuclide is assimilated into the tissues of plants and animals through biological processes (Peterson et al., 2007). Values of activity concentration of ^{40}K measured in soils from the Estação Ecológica de Assis (EEA) and from the Parque Estadual Carlos Botelho (PECB) are presented on Table 1. Samples collected in Atlantic Forest (Parque Estadual Carlos Botelho) presented higher activity concentrations of ^{40}K than those collected in Cerrado (Estação Ecológica de Assis).

Table 1. Activity concentration of ^{40}K in soils from EEA and PECB.

Descriptive statistics	Conservation unit	
	EEA	PECB
Mean (Bq.kg-1)	<77	1060
Standard deviation (Bq.kg-1)	-	209
n (number of samples)	27	27

Investigations about ^{40}K concentration on soil is quite useful as this element is an essential element of metabolism and can be found in all living cells, being absorbed by plants and animals through feeding. Particularly to the humans, this is the most predominant radioactive element in the tissues compounding the body (Peterson et al., 2007).

Plus, ^{40}K has a long half life, being responsible for 98% of gamma emission of primordial radionuclides present in the earth. Studies on K are also important because of its chemical similarity with Cs,

which is produced in the nuclear fuel cycle, contributing to internal dose to the occupational workers (Nair et al., 2014).

Shapiro-Wilk test was applied to check the data normality of the results for the Parque Estadual Carlos Botelho since the Estação Ecológica de Assis values have been lower than the minimum detectable activity. According to the histogram from Figure 1, ^{40}K activity concentrations presented normality at the 95% confidence level.

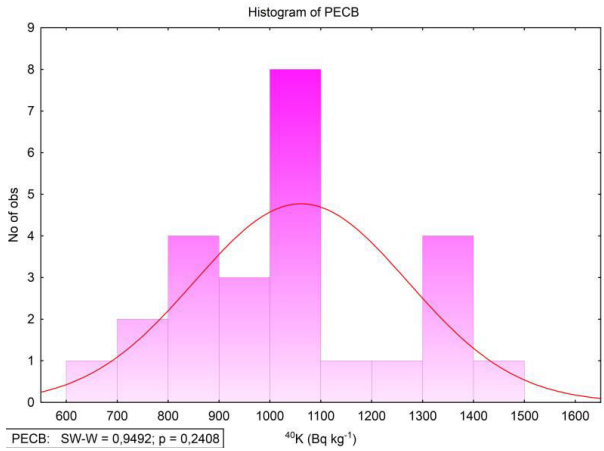

Figure 1. Histogram of the results obtained for determination of ^{40}K and verification of normality of results corresponding to the Parque Estadual Carlos Botelho (PECB).

According to UNSCEAR (2008), the specific activity concentrations of ^{40}K in soils ranging from 140 Bq.kg^{-1} to 850 Bq.kg^{-1}, presenting a mean of 400 Bq.kg^{-1}. Therefore, the activity concentrations obtained for the Atlantic Forest soils were above these values. However, the activity concentrations of potassium-40 determined in Cerrado soils were quite lower than the world wide average. Such difference between the results from Cerrado and from Atlantic Forest could be explained by the degree of soil development, since most part of the Atlantic Forest soils analyzed are inceptisol, that is, soils with the typical presence of parent material from rock weathering.

Besides, it can be assumed that potassium in soil can be limiting for Cerrado ecosystems.

Also, ^{40}K is preferentially related to sandy soil particles than to the interstitial water (in pore spaces between soil particles); it is also influenced by fertilizer use as, together with nitrogen and phosphorous, potassium is a major soil fertilizer, also being incremented in soils when fertilizers are applied. Plus, ^{40}K has high solubility and a very high transfer factor from soil to the food chain (Peterson et al., 2007).

4. CONCLUSIONS

Understanding the natural radioactivity contributes to improve the knowledge about the behavior of the isotopes in natural environment, and their path in the biogeochemical cycles. The present research evaluated the concentration of ^{40}K in soils of two conservation units corresponding to two biomes of world importance. The results showed that the concentration of ^{40}K at the Brazilian Cerrado was below worldwide values, however it was not observed the same pattern to Atlantic Forest concentrations of ^{40}K, as the values observed for this radionuclide were considerably higher than the world concentrations. It is worth to say that the behavior of any chemical element is affected by the soil conditions and its characteristics, it is also true for ^{40}K, as it was observed markedly differences between the concentrations of this radionuclide at the Cerrado and Atlantic forest soils.

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